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ASTRONOMICAL EXHIBITS AT THE EXPOSITION.

By Heber D. Curtis.

Those interested in astronomical science will find a number of very interesting displays at the Panama-Pacific International Exposition. The *piece de resistance* is doubtless the 20-inch equatorial for the Chabot Observatory, exhibited by Warner & Swasey in one of the main aisles of the Liberal Arts Building. This is a beautiful piece of work and attracts a good deal of attention.

The design of this telescope is on the same general lines as the well-known larger instruments of this firm. A ball thrust at the lower, and a live ring of steel rolls at the upper end of the polar axis relieve the friction of this portion of the instrument; the slow motion in right ascension is of the sector type as in all of the recent instruments made by this firm. This motion on the 36-inch refractor of the Lick Observatory is connected with the polar axis gearing so as to furnish a slow motion which is continuous and never "runs out;" with the sector type the necessity will occasionally arise to run the sector back to a middle position, but this drawback is more than counterbalanced by the greater cheapness, simplicity, and freedom from backlash given by the sector type of motion. Contact rings are built into the instrument on both the polar and declination axes to carry the illumination currents; the clock may be wound either by a small electric motor or by hand, and a clever arrangement of planet gears makes it possible to use either method without making any changes whatever. The telescope is equipped with two finders and with right-ascension setting circles mounted on the front of the pier, with a hand wheel for moving in right ascension. The driving clock is of the usual type, provided with a very clever and compact device for giving either sidereal or lunar rate. The telescope is provided with the traditional finely divided silver circles as well as the coarser setting circles which are all that are ever used in practice. The fine circles are employed solely, now-a-days, to get the accurate adjustment of the axes when the instrument is first set up, and after that are forgotten. Since the 36-inch refractor was erected I believe that the only time these fine circles have been really used was after the earthquake, to test whether the instrument was still in adjustment. All the necessary adjustments of an equatorial can be quickly made by photographs of the pole; several large reflectors, among them the Crossley and the 37-inch Mills reflector at Santiago, are totally unprovided with fine circles, and the same is true of the 30-inch photographic refractor of the Allegheny Observatory. The cost of finely divided circles is high, and one questions whether it would not be better to depend entirely on photographic methods for adjusting the polar axis and put the money thus saved into subsidiary apparatus.

WARNER & SWASEY also exhibit a fine 9-inch equatorial, and a 4-inch combined transit and zenith telescope with a number of interesting points. This instrument is provided with two latitude levels, one of which is attached permanently to the latitude vernier. The striding level is left permanently in place, with a device for relieving the pivots from its weight when not in use. They exhibit also a 2-inch altazimuth whose microscopes are provided with four filar micrometers; the circles and the latitude and striding levels read to one second of arc. A chronograph of standard pattern is shown, and the micrometer of the 20-inch equatorial. This micrometer is provided with two rapid motions in position-angle of the milled head and pinion type; one motion has twice the speed of the other. Photographs of the main instruments made by this firm are attractively displayed, as well as drawings of the great Canadian and Argentine reflector mountings, now in process of construction. A complete working model of the 72-inch Canadian reflector and dome will soon be added to the exhibit.

BRASHEAR'S exhibit is combined with that of WARNER &

SWASEY. Here are shown a full size reproduction of the 72-inch disk for the Canadian reflector and a fine collection of prisms and lenses of various types, including a 15-inch lens. Several fine gratings of fifteen thousand lines to the inch are also shown; the largest of these has a ruled surface 3.75 by 6.19 inches.

The astronomer will also find a number of points of interest in the very complete exhibits of surveying and other scientific instruments made by such firms as KEUFFEL & ESSER, BAUSCH & LOMB, LIETZ & Co., W. and L. E. GURLEY and others.

Besides an unusually complete and extensive assortment of surveying and geodetic instruments, KEUFFEL & ESSER exhibit several interesting periscopes and a Coast and Geodetic Survey tide-gauge. One should not miss, also, a novel sextant which they have on exhibition. The arc of this sextant is divided only into full degrees and there is no vernier. Instead the limb of the sextant is cut with very accurate worm teeth, into which meshes a worm moving with the arm of the sextant and provided with a divided head. A simple and handy little lever moves this worm into or out of mesh. In use, the arm is moved rapidly to the approximate position just as with an ordinary sextant, and when nearly in the correct place, instead of clamping the arm, the worm gear is dropped into mesh and the divided head turned till proper coincidence of Sun's limb and horizon is obtained. Then the reading of the sextant is given at once; the full degrees being read from the circle and the minutes and fifteen-second intervals from the divided head. It is much quicker and easier to read than an ordinary vernier. All depends, of course, on the accurate cutting of the worm teeth of the sextant limb, and only a series of tests can show whether the instrument would keep the accuracy required in use; accumulation of dust in the worm teeth might render it less accurate than a divided circle. Another convenience on this sextant is a small dry battery concealed in the sextant handle; from this battery a small bulb may be lighted by a button under the observer's thumb so as to illuminate the limb and the divided head for a reading. The same firm shows a ship's telescope with a finder of unusual interest. The telescope itself is provided with a neat device for changing the magnification from fifteen to forty-five without changing eyepieces or altering focus. Several years ago Professor TODD devised a finder for astronomical telescopes so fitted with right-angle prisms that the finder eyepiece could be placed close to the eyepiece of the main instrument. With a large instrument the finder eyepiece is two or three feet away in the ordinary form, and for some classes of astronomical work, e. g., double star work, where there must be constant intercomparison of finder and main telescope field, this distance between the two eyepieces entails, in the aggregate, a great deal of work. The finder of the ship telescope is a "broken" finder with two right-angled prisms, as in Professor TODD's scheme, but the eyepiece used for the finder is that of the main telescope, one of the right-angled prisms being fitted *inside the main tube* so that it can be quickly moved into or out of position in the axis of the main telescope by a light lever. By manipulating this lever, without moving the eye from the eyepiece, one can instantly change back and forth from finder to main field and *vice versa.*

Besides an excellent display of projection apparatus and microscopes, BAUSCH & LOMB exhibit several range finders, from small portable types up to a large one with a base line of twelve feet. They show also an 8-inch circle meridian theodolite and a 4-inch equatorial telescope. There is also a very large position micrometer with a number of special features. Besides the ordinary rapid longitudinal motion of the ocular a cross motion is provided as well. Clamps are provided for the various divided heads on the measuring screw. There seems to be no rapid motion for rotating the micrometer in position angle, and the slow motion for this is not very conveniently arranged. As a matter of fact, a slow motion for position angle in a micrometer is deemed unnecessary by practiced observers to-day, and that on the 36-inch micrometer has long been discarded. The micrometer is a beautiful piece of work, mechanically, but the simpler such a piece of apparatus can be made the better, and most practical astronomers would regard this piece of apparatus as too complicated.

Quite a number of adding and calculating machines are exhibited by various firms, and the astronomer will find this a very favorable opportunity to compare the different types.

Aside from the instruments mentioned which deal with the mechanical aspects of the science, there is but one purely astronomical exhibit at the Exposition, that of the Carnegie Institution. This is located in the Education Building, and no astronomer should miss seeing the beautiful exhibits shown here of the astronometric work done at Dudley Observatory and of the various fields covered by the activities of the Solar Observatory on Mt. Wilson.

The Lick Observatory has no exhibit at the Exposition, the Regents having decided that no exhibit should be made by any of the departments of the University of California, the nearness of the University to the Exposition making it its own exhibit.

The exhibit of the Dudley Observatory comprises a model of the *Taurus* cluster, photographs of the southern station at San Luis, Argentina, and a set of photographs and transparenies illustrating star-streaming, absorption of light in space, and kindred phenomena. The Mt. Wilson exhibit comprises a large set of excellent photographs displayed in swinging frames which show all the buildings and the more important instruments and pieces of special apparatus at Pasadena and Mt. Wilson. In addition a complete set of illuminated transparencies show the more important results secured in the spectroscopy of the Sun, sun-spots, stars and nebulæ and a splendid series of enlargements of photographs of nebulæ and clusters made with the 5-foot reflector. All in all, the exhibit is one before which everyone, astronomer or layman, will linger long and to which he will return again and again.